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DETAILED PROCESS DESCRIPTION

1.0 SYSTEM AND SUBSYSTEM VERIFICATION

1.1 APPLICABILITY THROUGHOUT THE SYSTEM LIFE CYCLE. The systems verification process is applied throughout the entire system life cycle which includes product development, test, manufacturing, distribution, deployment, support, training, and disposal. It is one of the Navy's core roles and responsibilities as an acquisition agent and "Smart Buyer". The verification activity carries out its responsibilities in parallel with and in synchronization with the product developer, acquisition agent (and it's technical direction agent). It serves as a representative of the Acquisition Agent. This includes in-process verification during product development as well as end item verification. The system verification process is applied during each level of system development (system, subsystem, and component) to determine a figure of merit or measure of effectiveness for the resultant products. The systems verification process is also applied during fabrication, assembly, integration and test, production, and consumer support phases and during system upgrades to improve performance or extend service life.

1.1 SYSTEMS/SUBSYSTEMS VERIFICATION RESPONSIBILITIES The Systems/subsystems Verification Activity must:

- Verify that a ***comprehensive engineering framework*** exists to enable proper specification and implementation of system performance, design, interface, support, production and test criteria has been established.
- Verify that a program ***strategy*** for generating iteratively refined designs at each development level exists.
- Verify that the engineering tradeoffs needed during iterations of the design process is appropriate and that ***program risk*** identification and mitigation processes have been properly effected.
- Verify that all ***technical performance requirements*** are fully considered, implemented, and tested during the proper phases of the system design and development process.
- Verify that all technical ***performance measures***, and schedules that will be employed on the program are proper, realistic, testable, and executable.
- Verify that the ***proper models and simulations*** will be employed in defining, developing, implementing and testing system requirements; optimizing system configuration; and performance verification.
- Verify that the overall system definition and specification properly identifies ***system hardware and software elements***.
- Verify that the fundamental needs which must be satisfied to enable system and subsystem ***integration*** have been addressed.
- Verify that the products of technical support ***specialists*** to produce an optimally balanced system design have been integrated.
- Verify that all ***test and life cycle cost*** considerations and requirements are fully considered in all phases of the system design process
- Verify that a program framework for ***logistics*** analysis, integrated logistics support (ILS) trade studies, and logistics documentation exists.
- Verify that a program framework is provided for ***production*** engineering analysis, producibility trade studies, and production/manufacturing documentation.

1.3 LIFE CYCLE PHASE INVOLVEMENT The verification activity will confirm the requirements baseline, functional and physical architectures, specifications and system baseline, system breakdown structure, and updated project and technical plans. The major factors addressed include:

- System Definition
  - System concept selection
  - Initial project and technical plans
  - System/subsystem risk
  - System constraints and limitations
  - System simulation and modeling requirements
  - Facility requirements
  - System specialty requirements
    - Safety
    - Testability
    - Producibility/Manufacturability
    - Verifiability
    - Operability
    - Supportability
    - Trainability
    - Disposability
- System specifications
  - System and product external interface specifications
  - System and product specifications
  - Subsystem interface specifications
  - Preliminary subsystem specifications
- Configuration baselines
  - System Functional Baseline
  - Preliminary subsystem baseline
- Technical Reviews
  - Trade Study analyses
  - Alternative Concept Reviews
  - System Definition Reviews

The verification activity will assure that the system as defined can satisfy operational requirements. The review documents will be verified to be sufficient to guide system/subsystem design. The technical reviews will be used to evaluate the maturity of the system development and the readiness to progress to the next phase of system development. The system life cycle events, operations, documents, and reviews which are subject to the verification process include:

- System Requirements Definition
  - System Requirements Review (SRR)
    - Functional Baseline Establishment
      - System Specification (A-spec)
      - External Interface Documentation
- System Design Definition
  - System Design Review (SDR)
    - Allocated Baseline Establishment
      - System Segment Specifications
      - Subsystem Development Specifications
      - Hardware/Software Specs (B-spec)
      - Internal Interface Documents
      - Preliminary design of subsystems
- Preliminary Design Approach
  - Preliminary Design Review (PDR)

Performance Specifications
Detailed subsystem component design
- Detailed Design Development
  Critical Design Review (CDR)
- Design Implementation
  Coding, Fabrication, Assembly, Integration
  Product Baseline
  Product/Fabrication specs
  SW Code
  Drawings
  Interface ControDocuments
- Test and Evaluation (T&E) Preparation
  Test Readiness Review (TRR)
- System/Subsystem End Item Test/Verification
  Verified Product Baseline
- System Validation
  Validated and Verified Product Baseline
  Production and Fabrication Specs
  SW Build Documentation
  Final Drawings
- Production and Manufacturing
- Installation/Delivery/Deployment
  Training
- Post Deployment Customer support
  Enhancements, Fixes

The verification activity ensures that each major exit event for each development phase of the system life cycle occurs satisfactorily. These major events include establishing product descriptions, completing specifications, establishing configuration baselines, and completing technical reviews. The verification activity analyzes design and process deficiencies/problems. Additionally, it makes recommendations relative to the products and facilities needed to satisfy total life cycle support requirements.

1.4 SYSTEM (SUBSYSTEM) VERIFICATION CRITICAL ELEMENTS The following is an overview and outline of those major processes, events, activities, and other factors that must be considered in performing the Systems Verification Function during the system life cycle. The verification Activity must ensure that the following elements have been properly addressed by the Navy Acquisition Agent together with the Product Developer.

1.4.1 CONCEPTUAL DESIGN IDENTIFICATION

1.4.1.1 INITIAL PRODUCT DEFINITION

- Customer Objectives, Needs and Expectations Identified
- Operational Requirements Identified
  - Threat Understood and Defined
  - "Problem to be Solved" Described
- Performance Requirements versus Technical Constraints identified
- Option/Trade-Off Analyses performed
  - State-of-the-Art and Enabling Technology
  - Make/Buy Decisions
  - Requirements Feasibility
  - Technical Alternatives, Design Alternatives and Options
- Risk Analyses Performed

1.4.1.2 SYSTEM DELIVERY CRITERIA AND SCHEDULES

- Deliverables and Customer Acceptance Criteria defined
- Incremental Deliveries Scheduled
  - Consistent with Customer's Schedules
  - Consistent with Production Capability
- Preplanned Product Improvement Strategy defined

1.4.1.4 SYSTEM CONCEPTUAL DESIGN

- Customer Requirements translated to System Requirements
- Conceptual Baseline Formulated and Documented (draft Type A Specification)
- Customer Acceptable System Development Plans and Procedures defined

1.4.1.4 SYSTEM REQUIREMENTS REVIEW (SRR)

The verification activity will ensure that there is agreement on a documented Acquisition/ Manufacturing Strategy and that the conceived system (documented in the Tactical and Systems Operational Requirements and Specifications) can meet the operational and mission needs and the Test and Evaluation Master Plan.

1.4.2 SYSTEM REQUIREMENTS DEFINITION

1.4.2.1 REQUIREMENTS DEFINITION CONSIDERATION FACTORS

- "Good" Requirements Characteristics defined
  - Attributes of Good Requirements and Minimum Standards understood
  - Guidelines/Tools for Writing Good Requirements adhered to
  - "Good" System Engineering Standards and Practices adhered to

- Hierarchy and Traceability well defined
  - Requirements/Design Engineering Tools Used
- Requirements Organized and Partitioned
  - Realism, Testability, Evaluation and Validation Criterion followed
- System Partitions and Interfaces identified.
  - Subsystem Partitions and Interfaces identified
- Interface Definition Standards employed
- Real-Time Requirements and Constraints considered
  - External Events and System Behavior
  - Speed and Precision of Response
  - Synchronous and Non-synchronous Processes
  - Inter-task Communication
  - Timing Conflicts
  - Data/Control Transformations
  - Concurrent Processes
- System Readiness Requirements addressed
  - RM&A, PM/FL/Diagnostics, System Test
- Integrated Logistics Support planned for
- Operational Considerations made
  - Man/Machine Interface
  - Mission Requirements
- Architecture well defined
- Commonality and Interoperability addressed
- Standardization addressed
- Software and Hardware Producibility and Maintainability addressed
- Specialty Engineering disciplines Integrated:
  - Quality
  - Human Engineering
  - Vulnerability and Survivability
  - Security

1.4.2.2 REQUIREMENTS DEVELOPMENT

- Systems Engineering Management Plan in place
- System Life Cycle Management Approach defined
- System Functional and Operational Requirements defined
- Test and Evaluation Master Plan factored in
- Functional Baseline Established (A-Specification)

1.4.2.3 SYSTEM PRELIMINARY DESIGN REVIEW (PDR)

The verification activity will ensure that there is agreement on the functional description of the system to be built and the process by which it will be produced, measured, tested and delivered. The verification activity will ensure that the Functional Baseline is documented.

1.4.3 SYSTEM DESIGN DEFINITION

1.4.3.1 REQUIREMENTS ANALYSIS AND DECOMPOSITION

- Design to Meet Performance Assessment made
- Computer Aided Systems Engineering (CASE) Tools used
- Design to Cost considered
- Prototyping and Design Iterations performed
- System Decomposition Rules and Methodology followed

1.4.3.2 SYSTEM REQUIREMENTS TO SYSTEM DESIGN FLOWDOWN

- Hardware/Software/Firmware Trade-Off Issues resolved
- Hardware and Software Resource Margins allocated
- Functional Allocation to Subsystems complete
- System Bottlenecks Identified
- Design and Implementation Trade-off Analyses performed
- Design Modeling, Prototyping or Simulation performed
- System Design Documentation (B-Specification) completed
  Allocated Baseline Specification completed

1.4.3.3 SYSTEM CRITICAL DESIGN REVIEW (CDR)

The verification activity will ensure that there is agreement on the system design selection from the alternatives and that the Program's "go-ahead and build" criterion are satisfied. It verifies that the system (as designed) needs to be built, can be built, and meets Customer needs with acceptable risk. It verifies that the System Allocated Baseline is documented and mutually agreed upon.

1.4.4 SYSTEM DESIGN IMPLEMENTATION

1.4.4.1 SYSTEM REQUIREMENTS FINALIZATION AND INITIAL DESIGN CONFIRMATION

- Requirements Iteration performed
- System Design Iteration performed
- Design Implementability Final Assessment performed
- Resource Usage Projection performed
- Subsystem Design Trade Study and Analyses performed
- Subsystem Design Verification Procedures in place
- Performance Shortfall Recovery Procedures in place
- System Design Validation and Certification Procedures in place

1.4.4.2 SYSTEM/SUBSYSTEM MODELING AND SIMULATION

- Modeling Needs and Model Selection Criterion established
- Capabilities and Limitations Determination made
- Feature Analysis, Simulation, or Prototyping done

1.4.4.3 SYSTEM DESIGN CONTROL

- Process Monitoring Methodology adhered to
- Metric Collection, Analysis and Processing performed
- Performance Baseline Configuration Control in place
- Design Control in place

1.4.4.4 SUBSYSTEM PERFORMANCE REQUIREMENTS

- Detailed Subsystem Performance Specifications produced.

1.4.4.5 SUBSYSTEM PRELIMINARY DESIGN REVIEWS

The verification activity will ensure that there the baselining of the performance requirements for the individual subsystems which make up the overall system has been done properly.

1.4.4.6 HARDWARE/SOFTWARE PRODUCT IMPLEMENTATION

The verification activity will ensure that the developer's engineering process assures that the subsystems meet their allocated requirements and can be integrated to produce the total system. Although the specialty disciplines areas are also crucial, hardware and software production is the typically largest part of the system engineering effort, at this point, and require the most attention by the verification activity.

- Software/Hardware Build and Integration Policy Established
- Software/Hardware Technology Assessed and Selected
- Software/Hardware Engineering Process Monitored

1.4.5 SYSTEM INTEGRATION

1.4.5.1 SYSTEM INTEGRATION PREPARATION

- Hardware/Software Subsystem Integration Strategy implemented
- Key Subsystem Integration Issues Identified and Resolved
- Subsystem Design Implementation Verification Methodology established

1.4.5.2 SYSTEM INTEGRATION AND VALIDATION

- Incremental System Integration Test Strategy established
  Test Cases Developed, Executed and Documented
- Design Verified and Validated
- System and Subsystem Interface Verified
- Issues Resolved

1.4.6 SYSTEM ACCEPTANCE TEST

- Test Plans, Techniques, and Strategies established
- Test Procedures and Operations documented
- System Test Performed
  Sufficiency and Completion Criterion Defined
  Specification Compliance Testing done
  Performance Testing done
  Customer Requirements/Needs Compliance Testing done
- Formal Reports, Reviews and Documentation generated
- Process, Product and Material Specifications (C-level and lower) generated
- Fault Tolerance Testing performed
- Failure Recovery and Error Correction Testing performed
- Alpha and Beta Site Testing performed
- Post-test Activity Planned

1.4.7 SYSTEM DELIVERY PLANNING AND SCHEDULING

- System Delivery
  - Capability and Constraints Defined
  - Release Description Documentation generated
  - Hardware Installation performed
  - Software Installation performed
- Operations and Maintenance Planning performed
  - Post-deployment Software Support planned
  - Post-deployment Hardware Support planned
- Operations Personnel Training accomplished
- System Enhancement- modification and product improvements addressed
- System Deficiency Correction accomplished

1.4.8 SYSTEM PRODUCTION SUPPORT

- System "Finalized"
  - Product Baseline Defined and under Control
- Non-OEM Sources Qualified
- Production Readiness Preparation accomplished
  - Feasibility Assessment done
  - Market and Production Risk assessed
  - Manufacturing Cost Containment addressed
- Production Readiness Review performed
- Production Plan in place

2.0 VERIFICATION METHODS AND TOOLS

2.1 FORMAL TECHNICAL REVIEWS The Formal Technical Review process is one of the primary interactive, information gathering and dissemination mechanisms for performing system verification. Therefore, the system verification activity will attend all relevant technical reviews, which include requirements and design reviews (system, subsystem, component, life cycle processes, test readiness, production approval) viz. the SRR, SDR, PDR, CDR, and TRR and audits (functional and physical configuration), for the purpose of assessing technical progress against requirements/design. Component and subsystem design reviews will be attended as appropriate for each level of development, also. Reviews will be attended for each subassembly, or product, as appropriate.

During the reviews the verification activity will:

- Assess the system requirements and allocations to ensure that requirements are unambiguous, consistent, complete, feasible, verifiable, and traceable to top-level system requirements.
- Assess the system design maturity based on Capability Maturity Models, technical development goals, systems engineering master schedule events and accomplishments, independent analysis, and test data supporting progress to date.
- Analyze Trade study and verification results in order to substantiate design decisions.
- Assess the risks associated with continued development.
- Recommend whether to proceed with the next phase of the systems engineering process, discontinue development, or take corrective action on the products and/or process of the current application before proceeding to the next application.
- Verify component, subsystem, and system functional configuration audits and physical configuration audits to ensure that tasks, activities, key events, and supporting documentation have been satisfactorily completed; that qualification tests for each specification requirements have been completed and all requirements satisfied; and/or that produced products comply with final drawings.

2.2 INFORMAL TECHNICAL INTERCHANGES/TECHNICAL COORDINATION MEETINGS
2.3 DOCUMENT REVIEWS
2.4 METRIC DEFINITION, COLLECTION AND ANALYSIS
2.5 FORMAL AND INFORMAL AUDITS
2.6 SIMULATION AND MODELING
2.7 TEST CASE EXECUTION

3.0 SYSTEM VERIFICATION ACTIVITIES (TBD)

3.1 INSPECTION/REVIEW

3.2 ANALYSIS

3.3 PROTOTYPING

3.4 SIMULATION AND MODELING

3.5 INDEPENDENT TESTING

3.6 DEMONSTRATION

4.0 SYSTEMS ENGINEERING ANALYTICAL SUBPROCESSES. The following subprocesses are invoked as appropriate during some or all of the system development phases.

4.1 Requirements Management TBD

4.2 Requirements Analysis and Validation TBD

4.3 Risk Management TBD

4.4 Trade Studies. TBD

4.5 FUNCTIONAL ANALYSIS.
The verification activity will perform functional analyses in order to scrutinize the system requirements and their implementation in greater detail. This activity may include the following:

System architecture analyses. The functional architecture will be verified to assure that it meets the requirements of the validated requirements baseline. The verification activity examines the functional architecture, appropriate to the level of development, to verify lower-level functional and performance requirements from which and for which lower level solutions will be determined.

System behavioral analyses

System state transition analyses

System Performance characterization and Benchmarking

(insert stuff from Jim Toth's EMSP dissertation on this subject here)

System timing analyses

Data and control flow analyses

Failure modes and effects analyses. The verification activity examines potential functional failure modes to verify failure effects and their critical impacts and the need for fault detection and recovery functions and procedures. Reliability models are established to support the analysis of system effectiveness for each operational scenario. Failures that represent significant safety, performance, or environmental hazards may be modeled to verify suspected system impacts.

Hazard analyses. The verification activity analyzes subfunctions and aggregates of subfunctions to eliminate operational hazards that could result in personal injury, property or product damage, or environmental impacts. Functional requirements for monitoring dangerous operational conditions, or notifying or warning operators of impending hazards, are verified.

4.6 FUNCTIONAL VERIFICATION

The verification activity shall assess the completeness of the functional architecture, appropriate to the level of development, to verify its ability to satisfy the validated requirements baseline. This activity may include:

Verification procedures: Define the procedures/methods for verifying the established functional architecture.

Requirements traceability: Execute the defined procedure to verify that each requirement and constraint described by the established functional architecture is upward traceable to the validated requirements baseline and that all top-level system requirements and constraints recorded in the requirements baseline are downward traceable to the functional architecture.

Architecture completeness: Verify that all top-level system product operational requirements included in the requirements baseline are traceable to and can be achieved by the functional architecture.

Performance measures: Recommend, define, collect, and analyze metrics.

System constraints: Verify that all system-level policy and procedural, standardization, functional, and physical constraints of the requirements baseline are traceable to the established functional architecture.

Variances and conflicts: Identify voids, variances, and conflicts. When functional architecture requirements are not upward traceable to the validated requirements baseline, it must be determined if non-required functions and/or performance requirements were introduced during functional analysis, or whether valid functional and/or performance requirements were introduced and need to be reflected in the requirements baseline. Non-required functions and/or performance requirements are identified for elimination.

Functional architecture verification: Verify functional architecture, with rationale justifying the structure, trade studies performed, and key decisions, in documented in an integrated database. This verified functional architecture is used to generate solutions to satisfy customer expectations and acceptance as defined by the validated requirements baseline.

4.7 PHYSICAL VERIFICATION.

The verification activity shall perform physical verification, in order to assure that the requirements of the lowest level of the physical architecture, including derived requirements, are traceable and have been implemented in the physical architecture (includes both hardware and software). It will assure that the physical architecture requirements satisfy the validated requirements baseline. This activity may include:

Verification Plan Generation. Identify the approaches for verifying the physical architecture and the scenarios for assessing design completeness. This plan will include:

• *Inspection, analysis, demonstration, or test requirements*. Select the appropriate verification method (inspection, analysis - including simulation, demonstration, or test) for evaluating whether functional and performance requirements, and physical characteristic identified in the system baseline are satisfied by the physical architecture. Develop a verification matrix to trace the verification method(s) to requirements of the functional architecture and requirements baseline. Select the models or prototypes to be used.

• *Verification procedures*. Define procedures for each verification method selected, identify the purpose and objectives of each verification procedure as well as the pre-test and post-test actions, and define the criteria for determining the success of failure of the procedure for planned and abnormal conditions.

• *Verification environment. identification* Define the environment including facilities, equipment, tools, simulations, measuring devices, personnel, climatic conditions, and check-out procedures.

Verification Performance. Verify that each requirement and constraint is traceable to the verified functional architecture and that the physical elements solutions satisfy the validated requirements baseline. Evaluate results to ensure that the behavior exhibited by the physical element solutions was correct and satisfies requirements. This includes:

• *Test Case Execution*

•• *Functional and performance measures.*.

• *Analysis of Test Results*

• *Architecture completeness*. Verify that physical element descriptions are traceable to requirements of the functional architecture (upward traceability), and the requirements of the functional architecture are allocated and traceable to the physical architecture. All internal and external physical interfaces must be upward and downward traceable to their source requirements

• *Satisfaction of constraints*

Variance and conflict Identification. When variances show incompleteness appropriate tasks are recommended to correct omissions. When evaluation results do not verify functional architecture requirements or when physical architecture requirements are not traceable to the functional architecture. it is determined whether non-required functions and/or performance requirements or physical elements were introduced or whether valid functional and/or performance requirements were introduced and need to be reflected in the functional architecture. Recommend elimination of non required functions and/or performance requirements. Recommend inclusion of missing requirements.

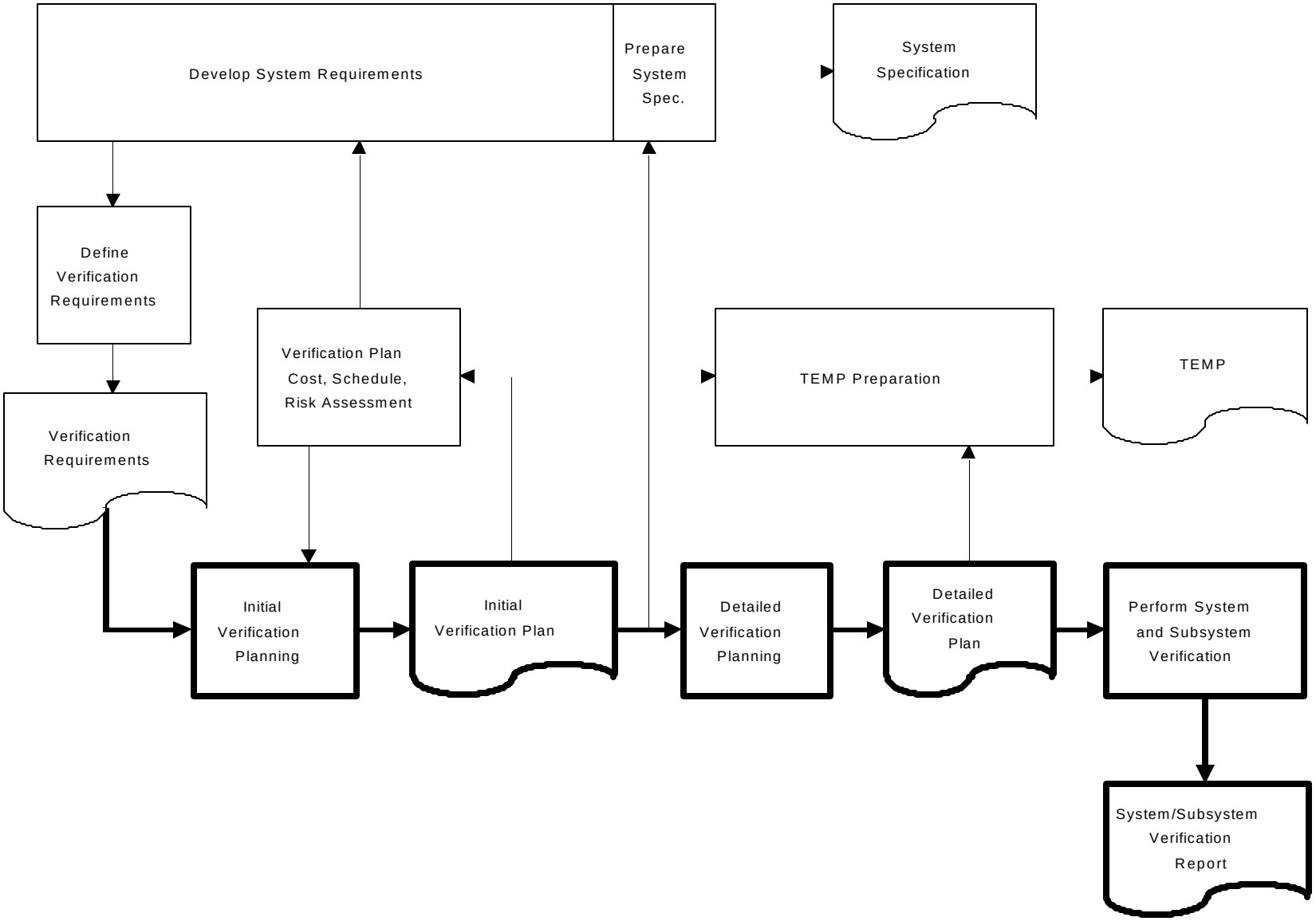
Physical architecture Verification. Verify architecture, with rationale justifying the structure, trade studies performed, and key decisions and document in the integrated database.

Ancillary Product Requirements Verification. Verify that the products associated with each life cycle process which must be bought or made, and integrated with other products related to the process or other processes, are done in a timely manner to support key project events.

Verified system architecture. Verify that a complete system architecture has been implemented and is composed of all life cycle process physical architectures and consumer product physical architectures.

Verify specifications and configuration baseline

Verify system breakdown structure.


Develop System Requirements
Prepare System Spec.
System Specification
Define Verification Requirements
Verification Plan Cost, Schedule, Risk Assessment
TEMP Preparation
TEMP
Verification Requirements
Initial Verification Planning
Initial Verification Plan
Detailed Verification Planning
Detailed Verification Plan
Perform System and Subsystem Verification
System/Subsystem Verification Report